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State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

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7 October, 2002

Subject: Sandhill Outdoor Skills Center High School Independent Studies Annual Report

Greetings!

The 2001-02 field season was the seventh year that the Skills Center offered an Independent Studies program to juniors and seniors from surrounding high schools. Forty-five students from 15 school districts participated in this year's program offerings.

Students are selected on the basis of academic ability and interest in science. All students attended a training session before joining an inter-school district field team. Data collection occurred Monday through Friday, and students reported to Sandhill on their assigned dates throughout the study period. Following the field season, students reassembled at Sandhill to analyze the data they had obtained. Many students were required to prepare reports for school credit as a result of participation in this program.

The enclosed report summarizes data collected in 2001-02 by students involved in both the Wolf-Deer and Porcupine Ecology studies. The enclosed summary was prepared by Skills Center staff to demonstrate the quality of work and capabilities of these highly motivated high school students.

Many thanks both to **Whitetails Unlimited, Inc.**, and **Consolidated Papers Foundation, Inc.** for their financial support of the Wolf-Deer and Porcupine projects.

Sincerely,

Dick Thiel, Coordinator
Sandhill Outdoor Skills Center

Laura Huber, Assistant

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Porcupine Ecology Study
Progress Report - November 2001 - April 2002

Sandhill Outdoor Skills Center
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*assisted with data compilation/analyses

Introduction

Porcupines (*Erithizon dorsatum*) are endemic to forested regions of Wisconsin (Jackson 1961). This species is well known for the damage it causes to forest trees; foresters and woods-persons alike have killed porcupines - on sight - for generations (Jackson 1961, Krefting et al. 1962). Aside from humans, fishers (*Martes pennanti*) are the porcupine's only significant predator. Porcupines began colonizing central Wisconsin in the mid-1970's (Thiel unpubl.). The relatively recent reestablishment of porcupines to this region provides an opportunity to witness how the porcupine population has responded to this previously unutilized forest resource, and to determine what impacts porcupines have on forest trees.

Study Area: The present study is restricted to the southern half of Sandhill Wildlife Area located in southwestern Wood County, Wisconsin. It is owned and managed by the Wisconsin Department of Natural Resources, Bureau of Wildlife Management. This 9,150-acre wildlife area is surrounded by a nine-foot tall, deer-proof fence. Half of the area consists of wetland complexes. Upland forest and small grassland openings, the largest of which is 260 acres, occupy the remainder. Porcupines have been present on Sandhill since about 1978 (Thiel unpubl). Fisher tracks were observed regularly in the southern half of Sandhill Wildlife Area this field season. This is only the second year that fisher sign has been observed in the study area since the beginning of the porcupine ecology study. No fisher population estimate is available for Sandhill.

The objective of the present study is to determine the demographics (age, sex and population size) and spatial organization of the porcupine population within the southern half of Sandhill Wildlife Area.

We hypothesize:

1) the relative age of porcupines can be determined by tooth wear and weight,
2) winter den availability is not presently a limiting factor, and
3) the porcupine population on Sandhill Wildlife Area is stable, but below carrying capacity.

Methods

Population Parameters and Demographics: Between November and April each year, porcupines occupy winter dens (Roze 1989). Searches were initiated by Sandhill personnel in November at den sites where porcupines were observed in previous winters. Additional den sites were found by systematically searching each woodlot in the southwestern quarter of Sandhill, looking for evidence of dens or porcupine trails. Den sites were considered "active" if a porcupine was seen, or if porcupine tracks or other fresh sign was present at the den. Den sites were considered "old" if there was no fresh sign present, but evidence of use in past years was found. "Potential" den sites were characterized by a hollow tree, log, hummock, or rock crevice that had potential for use, but no sign indicating use by porcupines. The location of each den was plotted on study maps along with its "active," "old," or "potential" classification. The acreage of each surveyed woodlot was determined by dot-grid analysis from aerial photographs. At the end of the field season, den densities were calculated by dividing the number of dens found by the total area of woodlots surveyed:

Den density (D_{den}) in the surveyed area:

$$\mathbf{D_{den} = Cumulative\ n_{den} \div Area_{Total\ surveyed}}$$

Minimum porcupine density was calculated for the study area by dividing the number of porcupines found by the total area surveyed:

$$\mathbf{Min\ D_{porcupine} = n_{captured} \div Area_{Total\ surveyed}}$$

Porcupine density was recalculated for the study area to include animals known to exist but never captured. The number of known, uncaptured animals were added to the number of captured animals and the sum divided by the total area surveyed.

$$\mathbf{D_{porcupine} = (n_{captured} + n_{known,\ uncaptured}) \div Area_{Total\ surveyed}}$$

Porcupines captured outside of the surveyed study area were excluded from this calculation.

Porcupines were handled after injecting them with Tiletamine Hydrochloride and Zolazepam Hydrochloride (Telazol®) (Hale et al. 1994). Porcupines were captured by hand injecting them in dens, placing traps at den entrances, placing covered, apple baited traps along feed trails, hand grabbing, or surrounding a roosting tree with one-m-tall chicken wire, along which a trap was situated. All captured porcupines were weighed, sexed, ear-tagged, and color-coded with spray paint to aid in identification from a distance. A Passive Integrated Transponder (PIT) tag (AVID Friendchip, 14mm) was injected between the shoulder blades of each porcupine captured.

Aging: Porcupine premolar/molar rows were examined and tooth replacement and wear were recorded. The sequence of tooth replacement allows for accurate aging of juvenile (age <1 year), yearling (age 1-2 year) and adult (≥ 2 years) (Kochersberger 1950, Roze 1989). Adult tooth wear was subjectively ranked as "no wear", "light", "moderate", or "heavy" based upon examination of porcupine skull specimens at the University of Wisconsin Zoological Museum.

Weight data were analyzed for potential as an age estimator. Data collected from 1998-2002 were combined and then separated by sex and age class (female: juvenile, yearling, adult; male: juvenile, yearling, adult) based on tooth replacement. The range and mean were calculated for each data set. Preliminary weight limits for each age class were determined.

Louse Infestation: Each porcupine was examined for louse (*Trichodectes setosus*) infestation in four body areas (ventral: thoracic and inguinal; dorsal: nape and rump). Infestation was rated subjectively as: 0 - no lice present, 1 - light infestation, and 2 - heavy infestation. A lice index for two-month periods was calculated by:

$$\textbf{Lice Index} = \Sigma\,[\,\Sigma\,(\text{lice infestation at sites 1,2,3,4})_{\text{porkies } 1..n}\,]_{\text{n porkies}} \div n_{\text{porkies}} \div \text{4 body sites}$$

Weight Change: Winter weight loss was calculated for the field season using individuals captured and recaptured between November and April of the field season. Average daily weight loss (W_{DL}) was calculated using the weight at capture and the weight at recapture.

$$W_{DL} = (\text{Weight Change}_{\text{initial capture – recapture}}) \div \text{No. Days Between Captures}$$

W_{DL} was compared with the corresponding Winter Severity Index (WSI) for the Central Forest region, Zone L (Sandhill DNR unpubl.). WSI is a relative measure using snow depth and temperature data for the period 1 December – 31 March.

$$\text{WSI} = \text{No. sub } 0^{\circ}\text{F days} + \text{No. days with} \geq 12 \text{ in. snow}$$

"Summer" weight gain was calculated using individuals captured and recaptured between February and December of the calendar year. Average daily weight gain (W_{DG}) was calculated using the weight at capture and the weight at recapture.

$$W_{DG} = (\text{Weight Change}_{\text{fall wt – spring wt}}) \div \text{No. Days Between Captures}$$

Mortalities: Porcupines found dead within the study area were necropsied by the DNR pathology section in Madison if found in good condition.

Home Range: Porcupine home range was determined after fitting animals with radio collars. Radio telemetry was used to locate individuals throughout the winter field season and into spring and summer. Each time an animal was located, its location was marked on a map and data were recorded on its location (tree species and tree DBH) and activity.

Results

Population Parameters and Demographics: A total of 631 acres (2.55 km^2) of upland habitat was surveyed in southwest Sandhill. Twenty-two active, old, and potential dens were located in the surveyed area (Table 1). Most of these dens were located in hollow trees, one was a rock den, and two were located underground at the base of uprooted trees. Density of active dens was 3.5 dens/km^2, while the density of all active, old, and potential dens combined was 8.6 dens/km^2 (Table 1).

Table 1. Winter porcupine den density in SW Sandhill Wildlife Area, WI, 1998-99 and 2001-02.

Den Type	Number found		Dens/100 acres		Dens/km^2	
	1998-99	2001-02	1998-99	2001-02	1998-99	2001-02
Active	9	9	1.3	1.4	3.3	3.5
Old or Active	9	11	2.7	1.7	6.6	4.3
Potential, Old, or Active	4	11	3.3	3.5	8.2	8.6

Assuming one porcupine per active den, nine porcupines were present in the surveyed area. Based on that assumption, porcupine density in the southwestern focus area was 1.4 porcupines/100 acres (3.5 porcupines/km^2).

A total of 24 different porcupines were captured in the entire study area's 1947 acres of uplands. Two of those individuals, both adult females, were originally captured in the 1996-97 field season. Minimum porcupine density was 1.2 porcupines/100 acres (3.2 porcupines/km^2). When porcupine density was recalculated to include animals known, but never captured (n = 7), density increased to 1.6 porcupines/100 acres (3.9 porcupines/km^2).

Fourteen of the 24 captured porcupines were found in the southwestern focus area, as were three other animals that were never captured. Minimum porcupine density within the southwestern focus area was 2.2 porcupines/100 acres (5.5 porcupines/km^2). Porcupine density within this same area was calculated to be 2.7 porcupines/100 acres (6.7 porcupines/km^2) when known, but uncaptured animals were accounted for.

Age-Sex Ratios: Tooth replacement and wear were used to determine age-classes among captured porcupines. Sixteen adults, four yearlings, and four juvenile porcupines captured in 2001-02 were examined and aged (Table 2). The female:male ratio for adult captures was 10:1 (Table 3). The female:male ratio for yearling captures was 1:3, while the female:male ratio for juvenile captures was 0.71.1. The female:male ratio for all captures was 2.3:1 (Table 4).

Table 2. Age-sex distribution of porcupines captured in Sandhill Wildlife Area, WI, 2001-02.

	Adult Female	Adult Male	Yearling Female	Yearling Male	Juvenile Female	Juvenile Male	Total
N Captured	20	2	1	4	2	2	31
% of Total Capture	64.5%	6%	3%	13%	6.5%	6.5%	100%

Table 3. Sex ratio of adult captured porcupines in Sandhill Wildlife Area, WI, 1996-2002.

	% Female	% Male	? /? ratio
1996-97*	88	12	7.3
1997-98	56	44	1.3
1998-99	62	38	1.6
1999-2000	77	23	3.4
2000-01	83	17	4.8
2001-02	91	9	10
Overall, 1996-2002	66	34	1.9

* two individuals were excluded because gender was unknown.

Table 4. Sex ratio of *all* captured porcupines in Sandhill Wildlife Area, WI, 1996-2002.

	% Female	% Male	? /? ratio
1996-97*	82	18	4.5
1997-98	57	43	1.33
1998-99	55	45	1.22
1999-2000	59	41	1.44
2000-01	60	40	1.5
2001-02	74	26	2.3
Overall, 1996-2001	52	48	1.1

* two individuals were excluded because gender was unknown.

Weight data for 1998-99, 1999-2000, 2000-01, and 2001-02 field seasons were combined by age class for analysis. The mean weight for adults was 15.6 lb (7.1 kg), while the mean for yearlings and juveniles was 8.7 lb (3.9 kg) and 5.5 lb (2.5 kg) respectively (Table 5).

Table 5. Weight ranges and averages by age and sex for porcupines captured in Sandhill Wildlife Area, WI, 1998-2002.

		Juvenile	Yearling	Adult
Male	High	7.0 lb (3.2 kg)	12.0 lb (5.5 kg)	20.3 lb (9.2 kg)
	Mean	5.8 lb (2.6 kg)	8.6 lb (3.9 kg)	15.7 lb (7.1 kg)
	Low	4.0 lb (1.8 kg)	5.5 lb (2.5 kg)	12.0 lb (5.5 kg)
Female	High	6.0 lb (2.7 kg)	10.5 lb (4.8 kg)	18.0 lb (8.2 kg)
	Mean	5.2 lb (2.4 kg)	8.3 lb (3.8 kg)	14.7 lb (6.7 kg)
	Low	4.0 lb (1.8 kg)	6.5 lb (2.9 kg)	11.0 lb (5.0 kg)
Overall Mean		5.5 lb (2.5 kg)	8.7 lb (3.9 kg)	15.6 lb (7.1 kg)

Louse Infestation: Heaviest louse infestation was observed in January and February. March and April had the lightest louse loading (Table 6). Juvenile and yearling porcupines exhibited a higher rate of infestation than their adult counterparts.

Table 6. Porcupine lice loading index by time period in Sandhill Wildlife Area, WI, 2001-02.

Time Period	No. Porcupines Sampled	Lice Index
November/December	5	0.85
January/February	16	0.87
March/April	4	0.81

Weight Fluctuation: No porcupines were captured and recaptured within the timeframe for calculating summer weight gain during this study period. Four individuals (two adult females, one yearling female and one adult male) were captured within the field season allowing calculations of winter weight loss to be calculated. Average winter weight loss was 0.02 lb/day (9.1 g/day) (Table 7).

Table 7. Porcupine seasonal weight fluctuation in Sandhill Wildlife Area, WI, 1997-2002.

Year	WSI	Ave. daily weight loss (g/day)	Ave. daily ? weight gain (g/day)
1997-98	29	12.9	9.5
1998-99	25	13.7	9.5
1999-2000	19	8.6	8.8
2000-01	142	N/A	N/A
2001-02	10	9.1	N/A

Mortalities: One juvenile female porcupine was found dead within an upturned tree root den. The body was collected. Necropsy results were not received in time for this publication.

Home Range: One adult male (Huber #81) and one adult female (Rudy #50) porcupine were fitted with radio collars. Rudy's radio failed and was removed the morning after capture. Huber was initially collared on 28 November 2001, and was recollared on 24 April 2002. Huber was located 15 times throughout the winter field season. His winter home range was 59 acres (23.6 ha), of which 32 acres (12.8 ha) was upland oak forest (Map 1). The remainder was composed of marshland.

Discussion

Porcupines selected hollow trees, hollows under uprooted trees, rock outcroppings, and culverts as winter dens. The highest den density was located on North Bluff in 2 escarpments. Rock outcroppings were preferred over hollow tree dens in other studies (Roze 1989, Krefting et al. 1962).

In the 1998-99 and 2001-02 field seasons, the same section of Sandhill Wildlife Area was surveyed. In the 1998 field season, 39 more acres were surveyed than in the 2001 field season. Regardless, the same total number of dens was found in 2001. Interestingly, the number of each *type* of den varied between years. Winter conditions between the 1998 and 2001 field seasons were similar (WSI of 25 and 10, respectively) in terms of little snow and relatively warm temperatures.

To calculate the minumum porcupine density, we assumed one porcupine per active den within the surveyed area. Our calculation of 2.2 porcupines/km^2 was based on nine active dens in the surveyed area. The propensity of den-swapping and inadequate trapping effort at active den sites leads to an inherent error in the assumption of one porcupine per active den. A “corrected” porcupine density of 2.7 porcupines/km^2 accounts for animals seen in the study area, but left uncaptured. Porcupine density is likely higher than these calculations. Winter porcupine density in the Hiawatha National Forest in Michigan’s upper peninsula was found to be 3.5 porcupines/km^2 without fishers present (Roze 1989). In the Ottawa National Forest in upper peninsula Michigan, porcupine density ranged from 11.8 porcupines/km^2 prior to fisher recolonization, to 0.8 - 2.8 porcupines/km^2 ten years following fisher recolonization (Roze 1989).

Porcupine density within Sandhill has probably not reached carrying capacity. Nine “old” dens were found within the surveyed area. These dens were used in past years, and were still useable during this study period. Four “potential” dens were found within the surveyed area, which could likely be used as winter den sites. This indicates that winter den sites are not a limiting factor for porcupines in the surveyed area. Long-term population data for porcupines on Sandhill is not available. Limiting factors acting on porcupines within Sandhill are unclear, but do not appear to be related to the availability of den sites.

Porcupine tooth replacement patterns allowed us to immediately separate young animals into the juvenile or yearling age classes. Tooth wear may allow us to subdivide adults into more specific age classes, but more data is needed, preferably a continual wear record for each individual we study. Tooth wear is currently used to age whitetail deer (*Odocoileus virginianus*) and other large herbivores. Tooth wear differs with diet and nutrition (Wilson 1996), but this problem should be overcome by developing an aging technique with porcupines local to Sandhill.

Body mass is a good indicator of age in medium and large-sized mammals because it changes so much during early development stages (Wilson 1996). During the last two field seasons, a relatively clear weight division between juvenile, yearling, and adult porcupines existed. There is certainly a clear weight division between the age classes when males and females are considered separately. The weight definitions have changed slightly with increased sample sizes, but we are confident these changes will continue to be slight. The sample sizes for juvenile and yearling animals are very small. A larger sample size is needed for both juvenile and yearling animals to attain a reliable data set. The sample size for adult females is robust. Additional adult males would increase reliability slightly.

In six prior studies outside Sandhill, female/male ratios have ranged from 1.08 to 1.91 for animals of all ages (Roze 1989). The observed sex ratio of 1.03 at Sandhill is nearer to a 1:1 female:male situation than any study. It is the result of five years of study and captures of 61 individuals. Our sample size of 61 is second lowest of all of the studies (range: 54 - 214), and this may account for some of the difference.

Roze (1989) proposed that nursing offspring pick up lice directly from their mother or from her shed fur in the spring. Neither explanation fits our observation of highest infestation in March and April, about the time animals are leaving their winter dens. We hypothesize that transmission of lice is likely a direct result of den sharing or switching during the winter months, as porcupines are primarily solitary animals during the rest of the year. We do not, however capture animals between May and November to observe lice loading trends throughout the year.

A new radio collar design was implemented for the 2001field season. In past field seasons, collar, backpack, and quill clip transmitters were used. None of the past designs was deemed acceptable due to injuries caused to study animals or loss of transmitters. The collar used this field season is made of nylon webbing within which the battery and circuitry is contained. When Huber's neck was examined five months after initial activation, no neck injuries were evident, though some neck hair had worn off. This collar design appeared safe and effective enough for continued use.

We thank Consolidated Papers Foundation, Inc. for their support of the porcupine ecology study.

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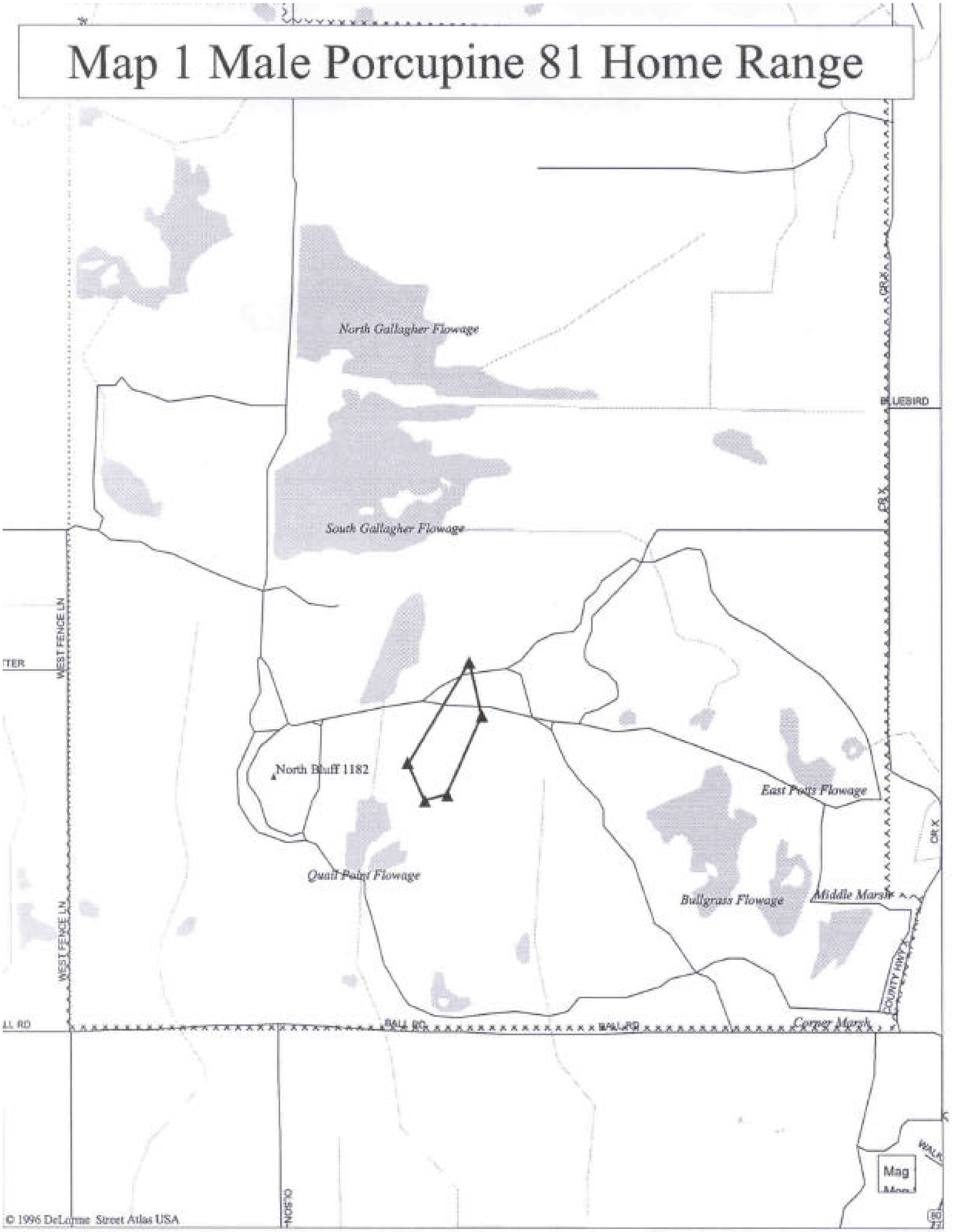
Map 1 Male Porcupine 81 Home Range
North Gallagher Flowage
South Gallagher Flowage
North Bluff 1182
East Potts Flowage
Quail Point Flowage
Bullgrass Flowage
Middle Marsh
Corner Marsh
WEST FENCE LN
BLUEBIRD
CR X
COUNTY HWY X
BALL RD
OLSON
Mag
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Deer - Wolf Ecology Studies

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* assisted with data compilation/analysis

Introduction

Sandhill Wildlife Area in southwestern Wood County, Wisconsin, a 9,150 acre facility operated by the Wisconsin Department of Natural Resources, is entirely surrounded by a 9-foot tall, deer-proof fence. Studies on deer (*Odocoileus virginianus*) herd age-sex composition, harvest impacts, and deer census techniques have been conducted on Sandhill since 1962. Much of the previous work has focused on aspects of human harvesting of deer.

Humans hunt deer for sport in highly regulated seasons. Wolves are predators of white-tailed deer (Mech and Frenzel 1971, Kolonosky 1972, Thompson 1952). Some deer hunters express concern that wolf predation may affect their success in hunting white-tails (McRae 1994, Pryse 1997).

Wolves (*Canis lupus*) have been absent from the Sandhill region since circa 1900, but recolonized the area beginning in 1992 (Thiel 1993). An adult male wolf escaped into Sandhill in May 1995 and has resided there since (Boehm 1997, Thiel 2000).

Until recently, canid predation (limited to coyotes [*Canis latrans*]< 1995) on deer in Sandhill was not considered appreciable. Assessing the impacts of predation requires that, “the number of wolves in an area, the number of prey animals in the same area, and the rate at which the wolves remove the prey" be known (Kolenosky 1972). Such quantitative data is difficult to measure. Further, factors such as snow depth and competition at kill sites with scavengers (mainly coyotes and corvids) influence kill rates (Fuller 1991, Paquette 1992).

The purpose of this study is to:
(1) determine the spatial partitioning of bucks and does,
(2) calculate survivorship trends among deer, and
(3) ascertain the influence of both human harvest and wolf predation on deer.

Methods

Weather. Data were maintained on daily temperatures, snowfall, and snow depth by students and DNR personnel at Sandhill Headquarters. A Winter Severity Index (WSI) measures the relative impact of winter weather on deer herd condition. The formula for the Central Forest WSI is:

WSI = # days < 0^{o}F +
#days with 6-11 inches of snow on ground+
2 X (# days with 12 – 17 inches of snow on ground) +
3 X (# days with > 17 inches of snow on ground)

Wildlife Populations. Annual coyote, beaver (*Castor canadensis*) and deer population statistics were gleaned from files maintained at Sandhill headquarters. Annual beaver colony counts provide the basis for long-term beaver population indices. Age-sex data are maintained on deer harvested by humans and deer dying natural deaths. Herd size and productivity are determined by irregular helicopter censuses and fall trail counts, and summer deer observations, respectively.

Wolf Study. Students entered the facility almost daily, Monday through Friday, working in teams of 1 to 4 people and walked, snowshoed, or drove along roads searching for wolf tracks. When tracks were encountered, students attempted to trail the wolves to locate prey remains. Students recorded information on distances traveled daily, and distances traveled on wolf trails.

Scats encountered on trails were teased apart to identify prey remains. Tracks adjacent to scats or the diameter of scats were used to distinguish between coyote and wolf droppings (Weaver and Fritts 1979). Kill-sites were inspected to determine the species, age and sex, and condition of prey at time of death. Vital materials such as jaws used in aging deer, were removed and given to DNR personnel for age analyses (Anon. n.d.). Samples of bone marrow, taken from the femur bone, were collected to determine health condition (Mech and DelGiudice 1985).

Deer Study. Deer were captured in a Grange Model box trap baited with hay. Captured deer were subdued by opening one trap door over which a net was suspended and pinning them to the ground. Radio transmitter collars were placed on selected deer while subdued. All deer captured were sexed and ear-tagged. Attempts were made to estimate age by inspecting wear on lower incisor teeth, and by assessing relative body size.

Deer were released at capture sites, and locations were obtained once weekly by determining direction of radio signals from pre-selected locations, recording bearings, and plotting triangulations on maps, as described by Mech (1983). Locations with large "errors of polygon" were rejected and not used in determining home range size. Deer locations were plotted on maps drawn from aerial photographs, and home ranges were determined by using the minimum area method (Mohr 1947 *in* Nelson 1981).

Impact of Wolf Predation. Age of predator-killed deer was compared to 2001 hunter-killed age statistics, and the age structure of non-harvested deer recovered in Sandhill between 1963 and 1994. Age stratification of the non-harvested deer cohort was assumed to represent herd age spread and was used to determine if humans and predators (wolves and coyotes) were selecting different age groups.

Utilization rates were determined by estimating the percent of each carcass that had been consumed by the wolf or coyotes, and returning to carcasses periodically to determine if each had been subsequently utilized. Consumption was calculated by determining the age and sex of deer when possible, and utilizing weight data on fall hunter-killed deer at Sandhill (Table 1) (DNR files), converting dressed weight to whole weight using the formula:

Whole Weight = 4.15 + 1.2487 x dressed weight

used by Kolenosky (1972). Daily consumption rates were calculated by taking this figure and multiplying it by the percent utilization of each carcass, and dividing by the number of days wolf trails were followed:

[3 (Whole Weight) x % utilization]) # days on wolf trails

Weights were expressed in kg.

Table 1. Mean dressed weights (kg) of Sandhill deer harvested in November 2001 (Sandhill DNR files).

Sex	Age						
	Fawn	**1**2	**2**2	**3**2	**4**2	**5**2	**6**2
Buck	24.1	39.8	57.8	61.3	-	-	-
Doe	21.9	36.7	40.2	45.2	50	50	51.3

The impact of wolf predation on the deer herd can be determined by calculating the number of deer preyed on by wolves using the following formula:

 # Deer Taken by Wolves Annually =

3_{Season} **[kg/Wolf/Day x # Days x % Deer in scats x # wolves**
) 0 Deer Wt (kg)]

where season is divided by monthly periods, and the mean deer weight is 54 kg.

Scavenging of deer gut piles and unretrieved deer killed by hunters following the deer hunting season is another potential food source for wolves and coyotes. Hunters were asked to report the location of any dead deer they encountered while hunting. These were inspected by DNR staff immediately following the hunting season to gain an impression of the volume of food available to canids following the November hunt. Age and sex were determined, and weights were calculated for each dead deer. Students inspected these carcasses at irregular intervals, noting incidences of scavenging by species, and amount. Consumption rates were calculated in the same manner as discussed above.

Results

Weather Data:

Work was conducted on 27 days between 2 January and 7 March 2002. A low of -11^{o}F was recorded on 18 January and 3 March, and a high of 57^{o}F was recorded on 8 February. Table 2 describes snowfall and mean depth, in inches, by month during winter 2001-02.

Table 2. Sandhill snowfall data, winter 2001-02.

Month	December	January	February	March
Total Snowfall:	**1**	**7**	**14.2**	**9.5**
0 **depth:**	**-**	**1.6**	**2.3**	**6.4**

The greatest stretch of continuous snow cover only extended over a 14-day period. The *Central Forest Winter Severity Index* for winter 2001-02 was 12.

2001-02 Predator and Prey Population Estimates:

The post-season deer herd was estimated at 550 deer (43.5 deer/mi^2) in Sandhill. Following a 21-year population low in 2001, beaver recovered slightly this year with 10 active colonies counted. Four to six coyotes were estimated to use portions of Sandhill during winter 2001-02. The lone, adult male wolf (named “Twisted Knee”) was the only wolf found within Sandhill. This wolf has been present on Sandhill since 1995 and is estimated to be 8 years old.

***Trailing Data*:**

Table 3 yields data on yearly effort exerted to find wolf sign from 1996 through 2002. Twenty-seven students from 7 school districts participated in the 22-day study. The total miles walked and driven, and the average daily miles walked and driven was similar the 7-year average of 179.7 and 6.9 miles, respectively (Table 3).

Table 3. Effort in searching for wolf sign, 1996-2002.

		Miles (km) traveled by Students					
Year	**# Days**	**Total Walked**	**Total Driven**	*0* **Walked Daily**	*0* **Driven Daily**	**Walked & Total**	**Driven** *0* **Daily**
1996	25	251.8 (402.7)	0	10.1* (16.1)	0	251.8 (402.7)	10.1* (16.1)
1997	35	202.4 (323.8)	63.7 (101.9)	5.8 (9.2)	6.4 (10.1)	266.1 (425.7)	7.6 (12.2)
1998	23	90.4 (144.7)	99.0 (158.4)	3.9 (6.2)	4.4 (6.9)	189.5 (303.0)	8.2 (13.2)
1999	19	52.8 (84.6)	15.75 (25.2)	2.8 (4.5)	15.75 (25.2)	68.6 (109.75)	3.6 (5.8)
2000	30	166.35 (266.16)	42.8 (68.5)	5.5 (9.5)	8.6 (13.8)	209.2 (336.6)	6.9 (10.2)
2001	28	63.4 (102.01)	47.8 (76.8)	3.5 (5.6)	5.9 (9.6)	111.2 (178.9)	3.9 (6.3)
2002	22	49.7 (80.0)	111.6 (179.6)	2.3 (3.7)	5.1 (8.2)	161.3 (259.5)	7.3 (11.7)
Ave	26	125.6 (200.9)	54.4 (87.0)	4.8 (7.7)	2.1 (3.4)	179.7 (287.4)	6.9 (11.0)

*This data represents 2, 2-person crews daily. Therefore, each 2-person crew averaged 5.0 mi/day.

Wolf Tracking Data:

Tracking data on wolf trails is presented in Table 4. This winter’s daily wolf trail encounter rate was 50 percent. This rate varies (range 37 to 76 percent); with most years falling in the area of 50-60 percent. The total miles tracked this winter (19.1) is lower than the 7-year average of 27.3 miles (map 1). One deer kill was found in 19.1 miles of tracking, compared to the 7-year average of 13.9 miles (range 4.7 to 28.8 miles).

Scats: Eight winter wolf scats contained 97 percent deer. Three wolf scats collected during the snow-free season contained 55 percent deer; 43 percent muskrat and 2.3 percent raccoon. Five winter coyote scats contained 55 percent lagomorph remains and 45 percent deer remains.

Kill Statistics: Remains of 1 predator-killed deer were located in winter 2002 (Tables 5 and 6).

Table 4. Wolf tracking data, 1996-2002.

Year	# Days Trailed	Daily Encounter Rate (%)	Total Miles (km) Tracked	0 Miles (km) Tracked/Day	Longest Daily Session	# Deer Kills Found	Miles/Kill (km/kill)
1996	19	76	28.8 (45.2)	1.5 (2.3)	4.6 (7.4)	1	28.8 (46.0)
1997	23	66	44.2 (70.7)	2.3 (3.7)	5.2 (8.3)	7	6.3 (10.1)
1998	14	61	26.3 (42.1)	1.8 (2.9)	5.2 (8.3)	4	6.6 (10.6)
1999	19	37	9.4 (15)	0.5 (0.8)	1.5 (2.4)	2	4.7 (7.5)
2000	15	50	31.75 (51)	2.2 (3.4)	5 (8)	2	15.9 (25.4)
2001	15	54	31.8 (51.2)	2.6 (4.3)	5 (8)	2	15.9 (25.6)
2002	11	50	19.1 (30.8)	1.7 (2.7)	4.5 (7.2)	1	19.1 (30.8)

Table 5. Cause of death of deer, by month, discovered January - March, 2002.

Mortality Type	January	February	March
Snow depth (in)	1.6	2.3	6.4
Wolf	0	1	0
Coyote	0	0	0
Starvation	0	1	0

Table 6. Age, sex and condition of predator-fed deer located in 2002.

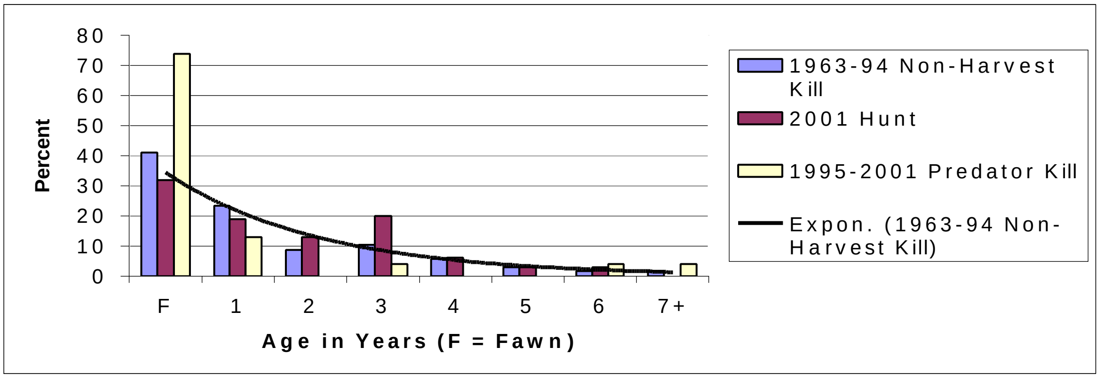
Map Loc	Date of Kill	Cause of Death	Sex	Age	Percent Consumed	Marrow Condition	Scavenged?
1	~2-5	Wolf	U[1]	U	95	white	no

[1]unknown

Age Selection: Twenty-three known-age predator kills (wolf and coyote) since 1995 are compared to the fall 2001 hunter-harvested deer, and non-harvest kills discovered in Sandhill between 1963 and 1994 in Figure 1. The age structure of non-harvested deer (also shown by line) is assumed to most closely represent the actual age structure of the herd. Predators and hunters select different age groups of deer:

predators selected primarily *young and some old* and hunters selected *prime-aged* (ages 1-4 years) deer relative to their occurrence in the herd.

Figure 1. Differences in age selection of deer in Sandhill Wildlife Area.



Kill and Utilization Rates, and Condition of Dead Deer: The 2001-2002 winter was characterized by little snowfall and light snow depths, mild temperatures, and the shortest contiguous duration of snow on the ground in the 7-year study (viz: 134 days of continuous snow cover in 2000-01vs 14 days in the present winter). The observed utilization rate was 95 percent on 1 wolf-killed deer (Table 6). Bone marrow color was white, suggesting that deer were not nutritionally stressed this winter.

Deer Telemetry:
Capture Efforts, 2002: Table 7 yields data on trapnights (TN) during the study. Nine deer were captured 15 times in 36 TN, for a success of 1 deer / 2.4 TN. Three "new" deer were radioed and 2 previously radioed deer were outfitted with new radios. Six radioed deer were monitored for portions of this winter study. Total trapnight effort varied from 32 in 1997, 44 in 1998, 38 in 1999, 18 in 2000, 66 in 2001, and 36 in 2002. Trapnights/capture ranged from 0.125 in 1997, 0.113 in 1998, 0.23 in 1999, 0.61 in 2000, 0.35 in 2001, and 0.41 in 2002.

Table 7. Deer capture success, Sandhill Wildlife Area, Winter 2002

Month	Trapnights	Unique Captures	Recaptures < 2002	Snapped Traps
January	**18**	**3**	**4**	**2**
February	**16**	**2**	**2**	**0**
March	**2**	**0**	**0**	**0**
Totals	**36**	**5**	**6**	**2**

Productivity Trends: Summer 2001 deer observations reflected a fawn/ doe ratio of 0.92, up significantly from 0.72 in 1998, 0.47 in 1999, 0.92 in 2000, and 0.90 in 2001. None of the 3 radioed does were observed in summer 2001 to determine whether they had fawns.

Survivorship Trends: Since this program began in January 1997, 8,578 deer-days (23.5 deer-years) of telemetry survivorship data have been accumulated on individual deer. Survivorship was calculated at 30 percent for bucks, 43 percent for does, and 23 percent for fawns. Cause-specific mortality (Table 8) varied with age and gender: starvation was most prominent amongst bucks (n=3) and fawns (n=2), and hunting harvest was the predominant cause of death amongst does (n=4). Wolf predation accounted for 1 buck.

Table 8. Cause-specific mortality in Sandhill radioed deer, 1997-2002

Category	Bucks	Does	Fawns	All
RadioDay Total	2457	5121	1000	8578
Death by Wolf	1	0	0	1
Death by Hunter	0	4	0	4
Death by Starvation	3	2	2	7
All Deaths	4	6	2	12

Home Range Size (Map 2): The size of 3 adult doe home ranges averaged 192.6 acres (range 112-332 acres). Two buck home ranges averaged 809.5 acres (range 365-1,254 acres).

Impact of Wolf Predation on Sandhill Deer Herd
Consumption Rate of Wolf: Based on the kill remains located in 2002, a consumption rate of 4.3 kg of meat/day was calculated for the Sandhill wolf during the 22-day study period (Table 9). This is close to this study's 7-year average of 4.7 kg of meat/day, and to the 4.4 to 6.3 kg/wolf/day estimated from Isle Royale (Mech 1966). It is higher than the 2.8 kg/wolf/day reported for a pack of 8 wolves studied by Kolenosky (1972) in Ontario, and 2.5 kg/wolf/day reported by Mech and Frenzel (1971) in northeastern Minnesota.

Fall Scavenging Potential - Harvested Deer Gut Piles and Unretrieved Kills: Hunters harvested 178 deer in November 2001. This represents 1505 kg of gut piles; all potential food for wolves and coyotes. In addition, 27 unretrieved hunter-killed deer carcasses were discovered for an additional 1187.5 kg of potential food for canids. Between gut piles and unretrieved hunter losses, 2692 kg of carrion remained in the wake of the hunt; 192.3 kg (423 pounds) per square mile!

Table 9. Consumption rate of wolves in Sandhill, 1996-97 to 2001-02.

Location	Number of Wolves	Year	Deer Density deer/mi^2 (deer/km^2)	Ave. mi (km) per kill	Ave. days per kill	Days/Kill/Wolf	Food/Wolf/Day (kg)
Sandhill	**1**	**1996-97**	**24.7 (15.4)**	**6.3 (10.1)**	**4.5**	**4.5**	**4.4**
Sandhill	**3**	**1997-98**	**25.0 (15.6)**	**6.6 (10.5)**	**3.5**	**10.5**	**4.2**
Sandhill	**1**	**1998-99**	**25.0 (15.6)**	**13.0 (21)**	**7.0**	**7.0**	**2.8**
Sandhill	**1**	**1999-2000**	**29.0 (18.1)**	**N/A**	**7.5**	**7.5**	**5.0**
Sandhill	**1**	**2000-01**	**32.1 (20.1)**	**15.9 (25)**	**7.5**	**7.5**	**7.1**
Sandhill	**1**	**2001-02**	**51 (31.9)**	**N/A**	**N/A**	**11**	**4.32**

Table 10 breaks down the calculation of deer taken on Sandhill by season. In the present biological year (1 June 2001 to 31 May 2002) the wolf consumed the equivalent of 19 deer. Over the 6-year study, this figure has ranged from 14 to 37 deer/wolf/year. This does not include any compensation for scavenging on gut piles.

Discussion

This was the mildest winter in the 7-year study. The only wolf was the lone male who entered the facility in May 1995.

Percent utilization of deer carcasses by canids between 1996-2002 appears to be inversely related to winter severity (Figure 2). Daily consumption rates by the wolf in winter appear to be related to previous autumn deer densities (Figure 3).

Figure 2. Percent utilization of deer carcasses by coyotes and a wolf on Sandhill compared to WSI, 1996-2002.

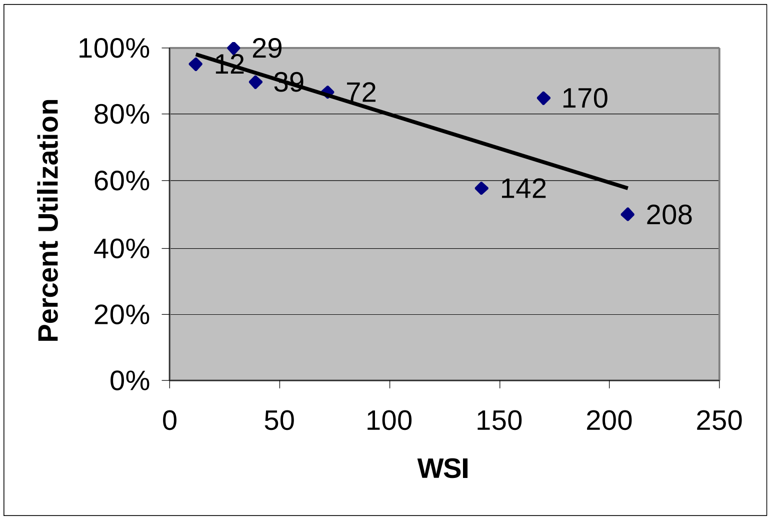
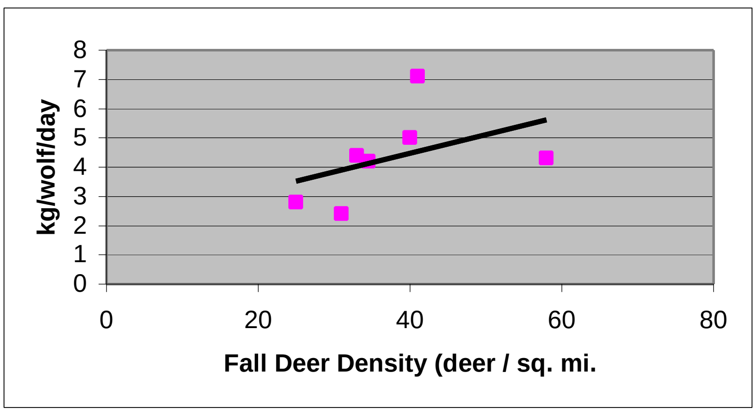


Figure 3. Daily winter consumption rates of a wolf in relation to autumn deer densities, 1996-2002.



This single wolf consumed an estimated 19 deer on Sandhill in 2001-02. The average number of deer harvested annually by hunters is 92 deer (Table 11). Wolf predation on deer in Sandhill is probably an *additive* source of mortality for deer. However, humans normally harvest fewer deer annually from the Sandhill herd than are recruited through reproduction. The combined effect of a human harvest averaging 92/year and wolf predation averaging 23/year has not prevented an increase in the mid-winter deer population from 351 deer in 1998-99 to 550 deer in 2001-2002. Additional deer need to be harvested to reduce the likelihood of starvation in future winters.

Table 10. Calculated annual "take" of deer by wolves on Sandhill, March, 2001 – February 2002.

Period	Kg/Wolf/Day	# Days	% Deer in Scats	# Wolves	Total Wt (kg) Consumed	Total Weight)0 Deer Wt	Total Deer
June – Aug 2001	4.3	92	55	1	219	54	4
Sep – Nov	4.3	92	55	1	219	54	4
Dec – Feb	4.3	91	97	1	381	54	7
Mar – May 2002	4.3	90	55	1	219	54	4
Year 2001 – 02 Sum				1	1038		19

Table 11. Deer harvest and population trends, Sandhill Wildlife Area, 1995-96 through 2001-02.

Biological Year	1995	1996	1997	1998	1999	2000	2001	Ave
Hunter Harvest	63	54	76	62	133	79	178	92.1
Wolf	14	20	37	23	20	27	19	22.8
Total	77	74	113	85	153	106	197	114.4
Deer Trail Survey[1]	382	402	422	306	490	504	428	
Helicopter Census[2]		346			351	450	550	

[1]fall survey before hunting season [2]winter count following hunting season

Recommendations:

(1) Continue to monitor canid predation and assess consumption rates of wolves and coyotes on Sandhill,
(2) monitor radioed deer to determine *annual* home range sizes, and maintain contact with an average of 6 adult deer per year in the SE study area,
(3) determine fawn recruitment of radioed does in Sandhill,
(4) place ear-tag transmitters on 2-4 fawns in winter 2002-03,
(5) obtain at least 25 radio locations per year to assess deer home range sizes, and
(6) conduct liberal hunt to reduce the Sandhill deer population.

We thank Whitetails Unlimited, Inc. for their continued support of the deer telemetry study conducted by high school students.

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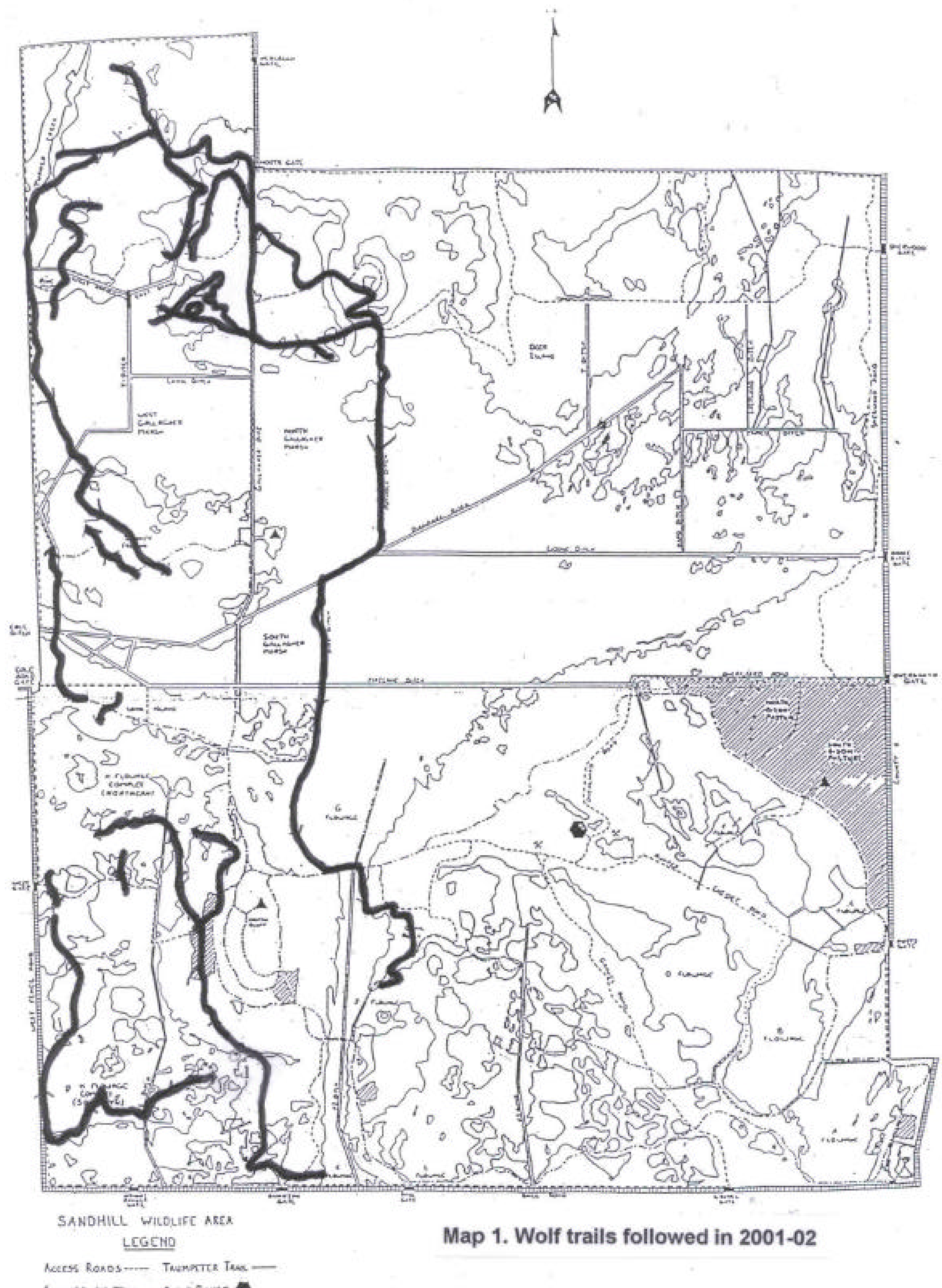
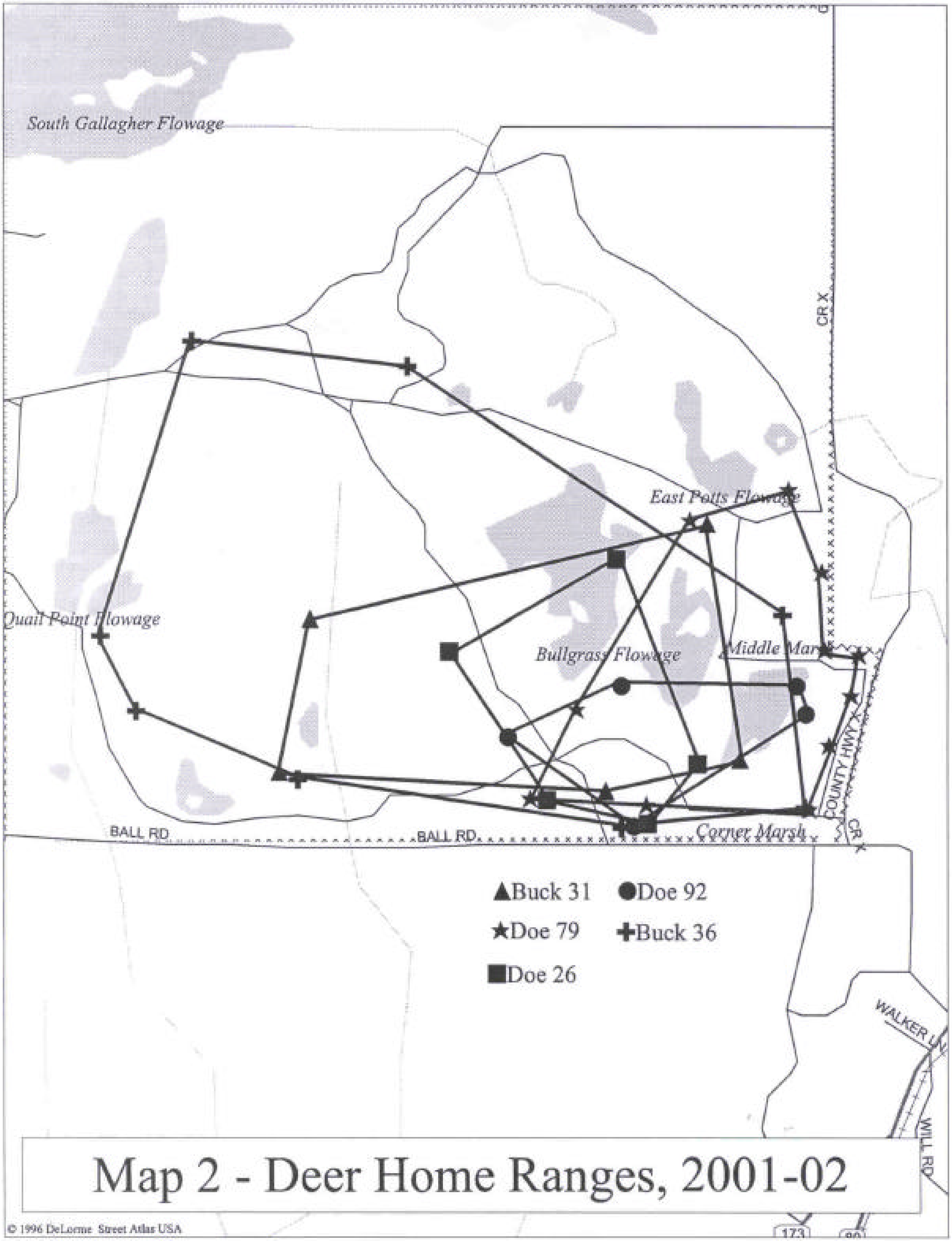
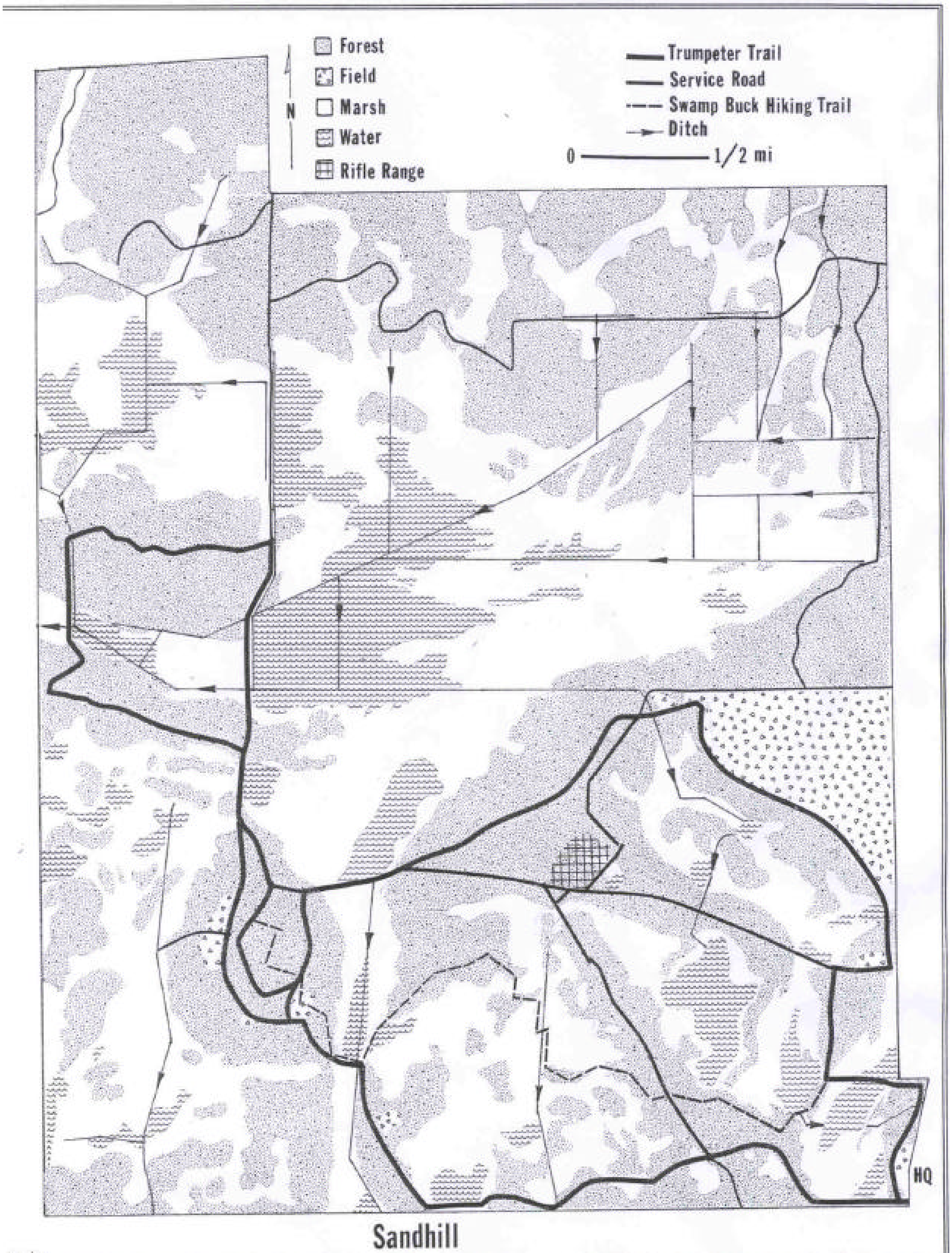


Map 1. Wolf trails followed in 2001-02



Map 2 - Deer Home Ranges, 2001-02


Forest
Field
Marsh
Water
Rifle Range
N
Trumpeter Trail
Service Road
Swamp Buck Hiking Trail
Ditch
0
1/2 mi
HQ

Sandhill